Dust contamination of ice drills

Klaus Helbing and Jodi I. Lamoureux

June 5, 2003

Here is a little *back of the envelope* calculation of how much dust is needed to reduce the scattering length to the low value of about $l_{\rm scat} = 0.5$ m that has been observed.

Assume – as has been done for bulk ice too – the radius of the dust is of the order of the wavelength $r_{\rm d} \simeq 300$ nm. Assume also that air bubbles do not play a significant role in the scattering. The cross section for scattering in the simplest ansatz would be $\sigma_{\rm d} = 2\pi r_{\rm d}^2$. The volume of the scatterer is $V_{\rm d} = \frac{4}{3}\pi r_{\rm d}^3$. Let $f = N_{\rm d}/V_{\rm h}$ be the number of scatterers (dust particles) per volume of hole ice. The the number of scattering $N_{\rm scat}$ interactions within a length l the photon travels then reads $N_{\rm scat} = \sigma_{\rm d}\ l\ f$. On the other hand $N_{\rm scat} = l/l_{\rm scat}$. Resolving this with respect to f gives:

$$f = (2\pi r_{\rm d}^2\ l_{\rm scat})^{-1} \simeq 3.5 \cdot 10^{12} \text{ dust particles per 1 m}^3 \quad .$$

With the Volume of a drilled hole in the ice $V_{\rm h} = 2\pi r_{\rm h}^2\ d$ and $r_{\rm h} = 0.5$ m, $d =$ 2 km being the radius and the depth of the hole, one obtains for the total volume of the dust $V_{\rm d}^{\rm tot}$ in the drilled hole:

$$V_{\rm d}^{\rm tot} = f\ V_{\rm d}\ V_{\rm h} \simeq 1 \text{ liter dust in the whole hole.}$$

This seems a very little amount of dust or dirt that could easily enter for example with the surface of the hose for the hot water. Does this calculation make any sense??

PS: Jodi should not be blamed for the exact phrasing.